Marathon's Bakken Well Vertical Seismic Profile and Tiltmeter Fracture Stimulation Monitoring

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Subsurface Manager

September 20, 2007

Marathon

Marathon After a Year in the Williston Basin

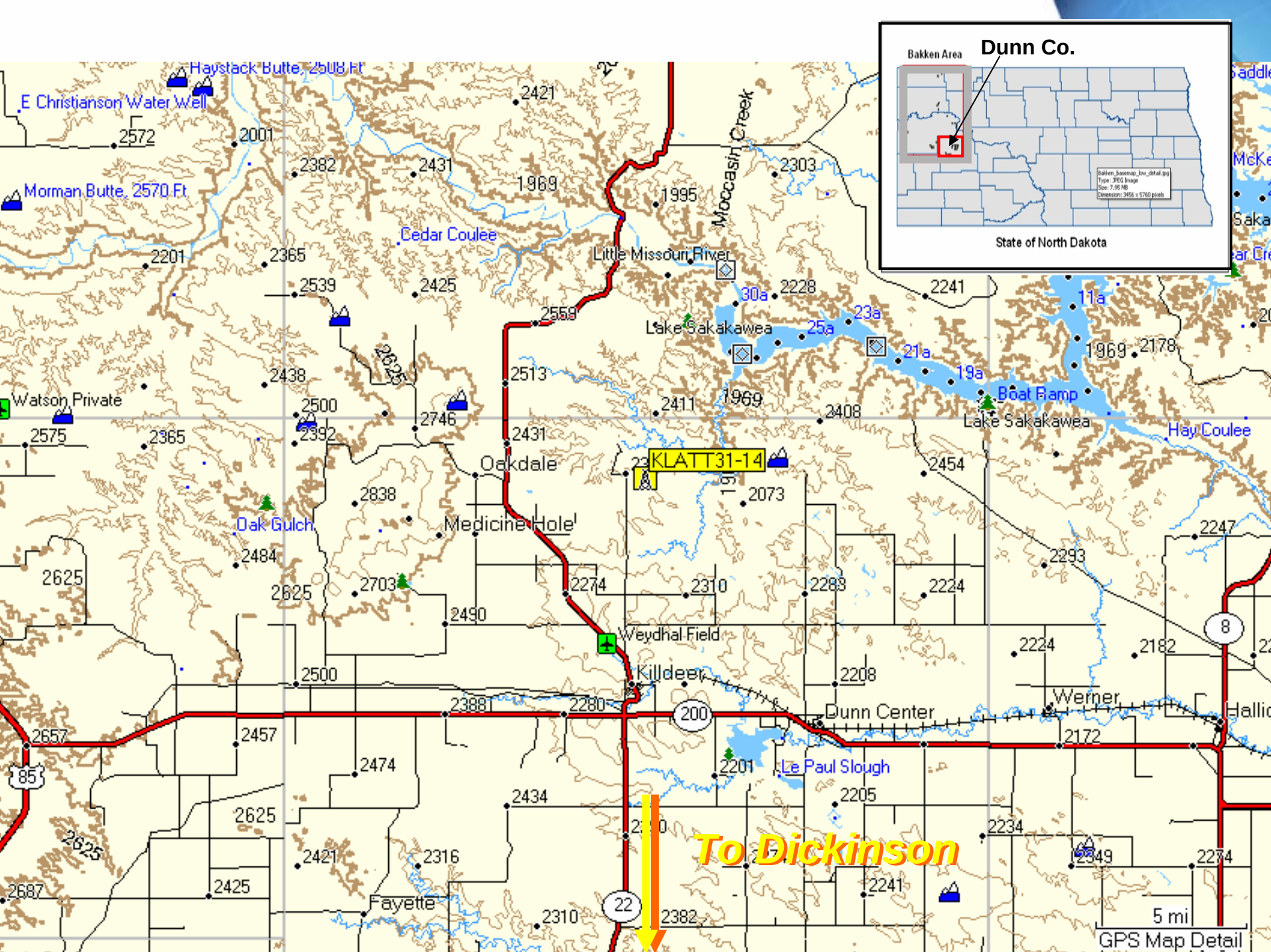
- Production Office Opened in Dickinson
  - New Building Opening by November
- Operating Safely While Building Infrastructure, Increasing Staff and Industry Ramp Up
- Six Rigs Running Including 5 H&P New Rig Start Ups
- Rigs are Concentrated in Dunn County
  - Marathon Operated Over 20 wells in 6 Project Areas
  - Participants in Several Other Outside Operated Wells
- Approach
  - Work with North Dakota
  - Technology Application in all Facets

Today - Update of Completed NDIC Petroleum Research Council Grant Work

- G-10-C: Vertical Seismic Profiling Test of a Seismic Fault and Fracture Detection in the Bakken Formation
- G-10-B: Surface Tiltmeter Study of a Bakken Fracture Stimulation
- Both Acquired in Marathon Klatt 31-14H, Dunn County During 2007
- Results Out to Public in June 2008

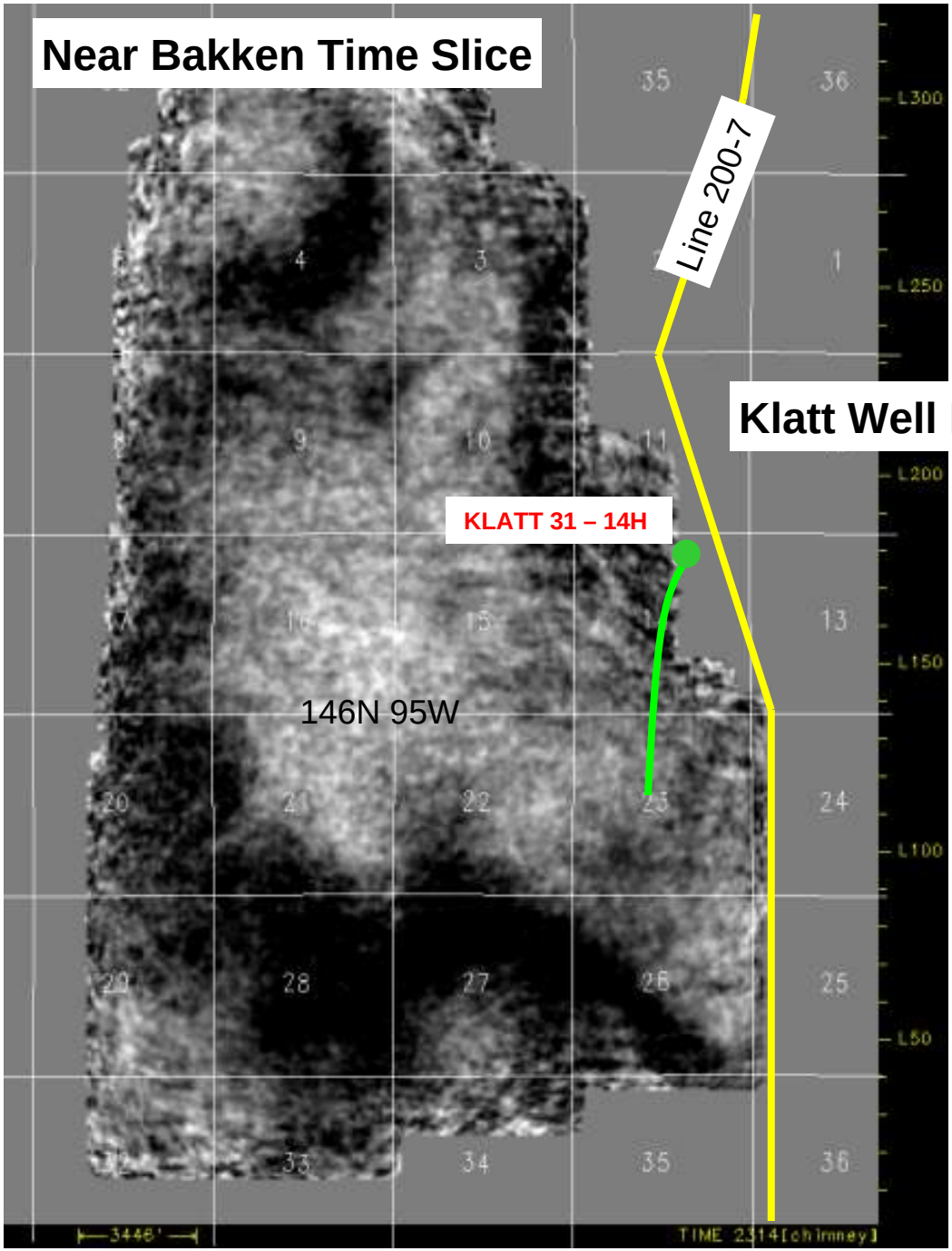
Acknowledgement

- North Dakota Petroleum Council Encouragement
- NDIC - Karlene Fine


Bakken Area
Dunn Co.
State of North Dakota
Haystack Butte, 2508 Ft
E Christianson Water Well
Morman Butte, 2570 Ft
Cedar Coulee
Little Missouri River
Moccasin Creek
Lake Sakakawea
Boat Ramp
Hay Coulee
Watson Private
Oakdale
KLATT31-14
Oak Gulch
Medicine Hole
Weydhal Field
Killdeer
Dunn Center
Werner
Le Paul Slough
Fayette
To Dickinson
5 mi
GPS Map Detail

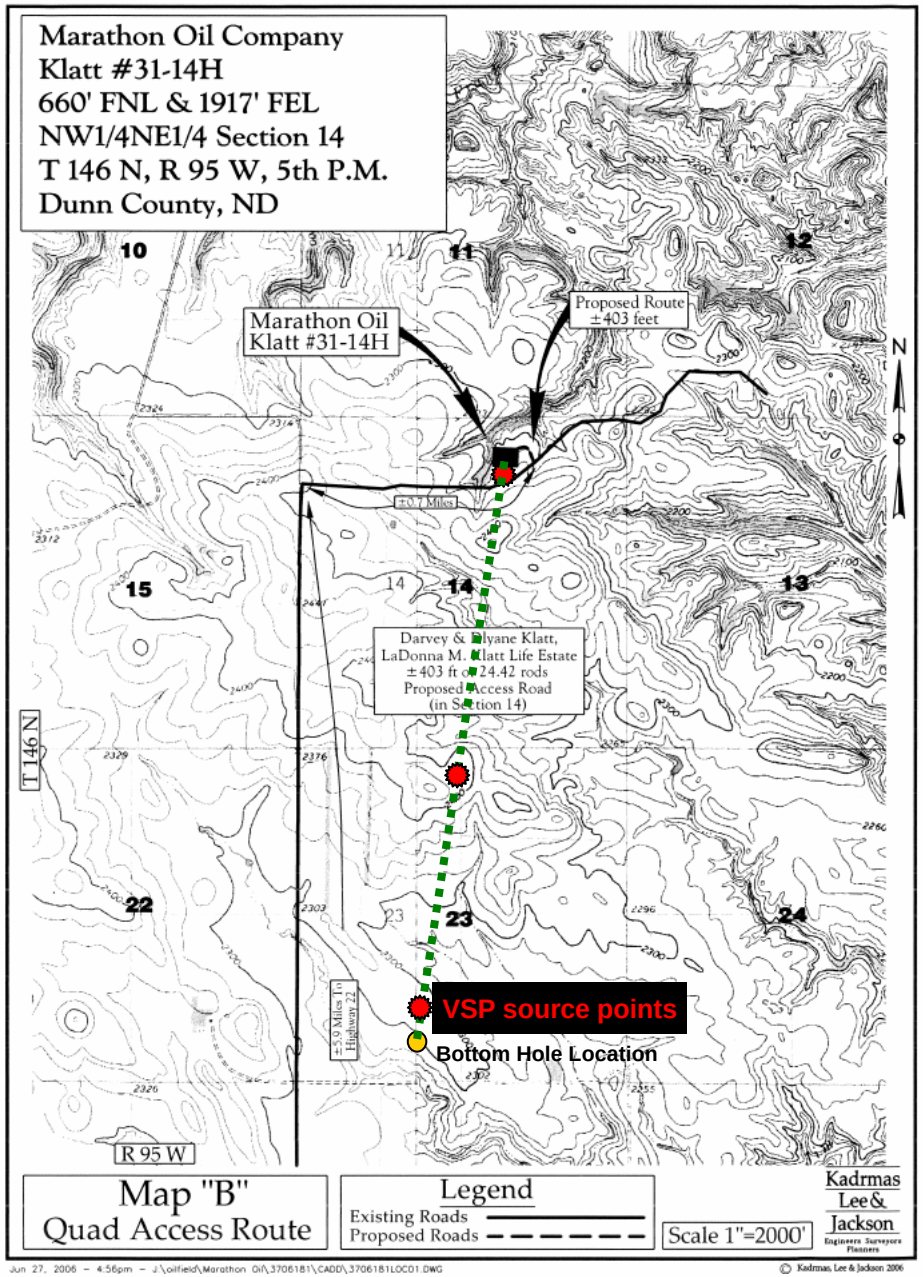
VSP- Vertical Seismic Profile

- Purpose – Acquire VSP to tie to seismic for Bakken evaluation
- Plan – Acquire zero offset and two additional offsets along well path
- Contractor – Baker Atlas
- Cost - $240 M for survey
  - Two days of rig time
  - On budget
- Execution – Completed without difficulty
- Status – Processing and incorporating into data sets
- Marathon Contributors – Chuck Meeder, Geophysics and Erin Wanner, Land



Klatt Well Near 2D line and on 3D Survey

VSP Layout


Marathon Oil Company
Klatt #31-14H
660' FNL & 1917' FEL
NW1/4NE1/4 Section 14
T 146 N, R 95 W, 5th P.M.
Dunn County, ND
Marathon Oil
Klatt #31-14H
Proposed Route
±403 feet
±0.7 Miles
Darvey & Elyane Klatt,
LaDonna M. Klatt Life Estate
±403 ft or 24.42 rods
Proposed Access Road
(in Section 14)
±5.9 Miles To
Highway 22
VSP source points
Bottom Hole Location
T 146 N
R 95 W
N
Map "B"
Quad Access Route
Legend
Existing Roads
Proposed Roads
Scale 1"=2000'
Kadrmas
Lee &
Jackson
Engineers Surveyors
Planners

Job Details

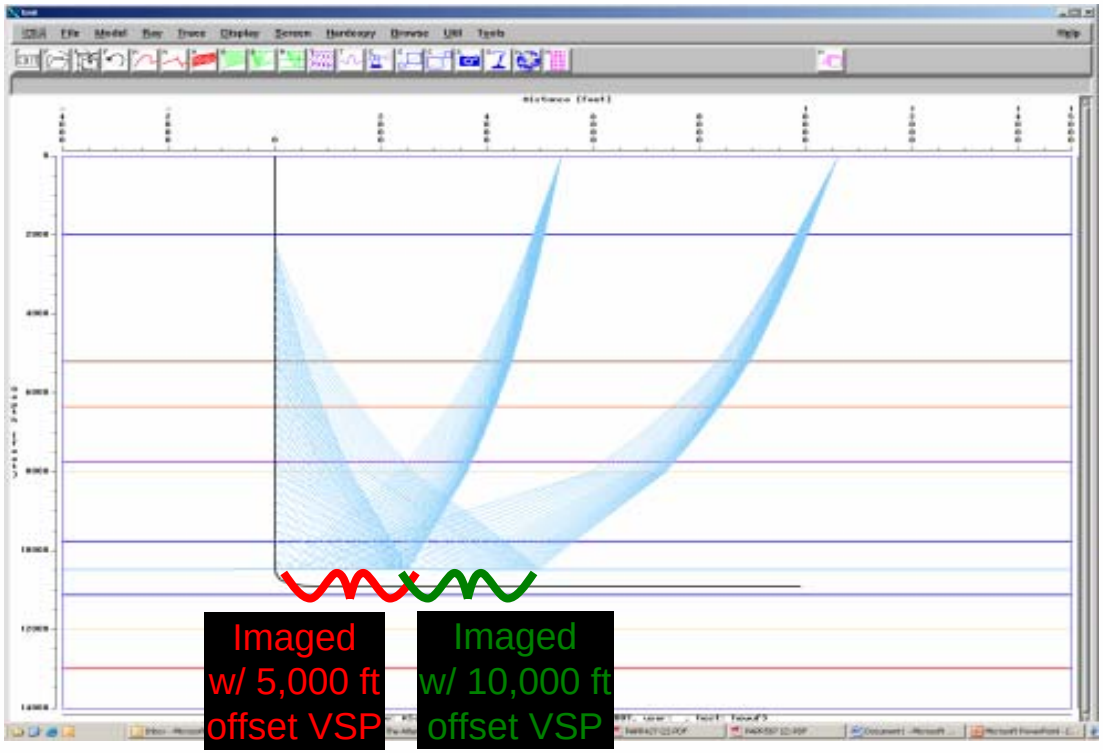
2 source points

200 ft south of well head
about 5,000 – 10,000 ft out the lateral

Sensor locations

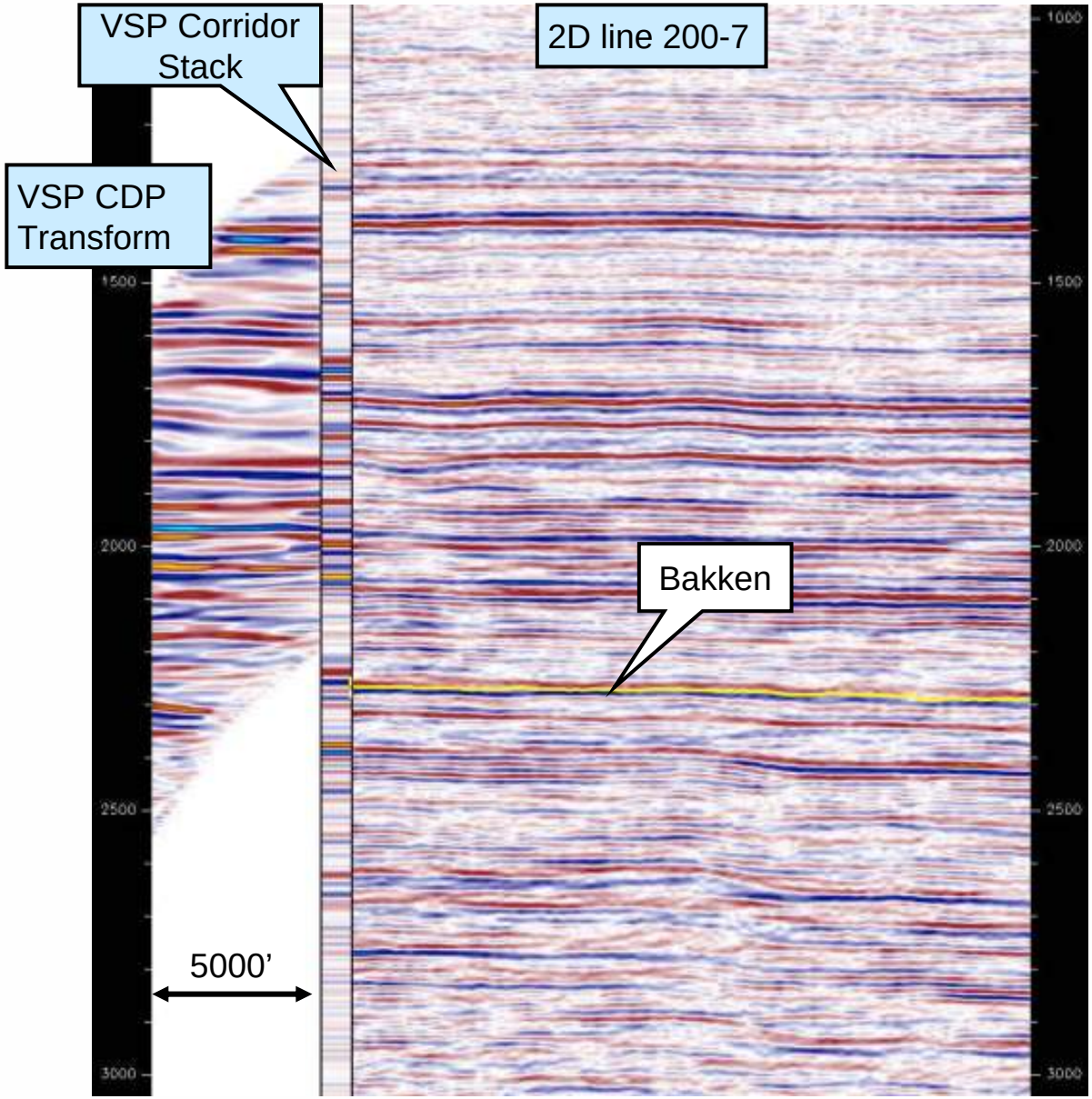
50 ft interval from 10,900 to 2,500 ft **169 levels**

500 ft interval from 2,000 to 500 ft **3 levels**



- Zero Offset VSP to provide a tie to the seismic and to give better parameters on attenuation and velocity
- 5000 ft offset VSP to image first 2500 ft of lateral
- 10600 ft offset VSP to image lateral section from 2500 ft to 5000 ft

Result – Quality Data

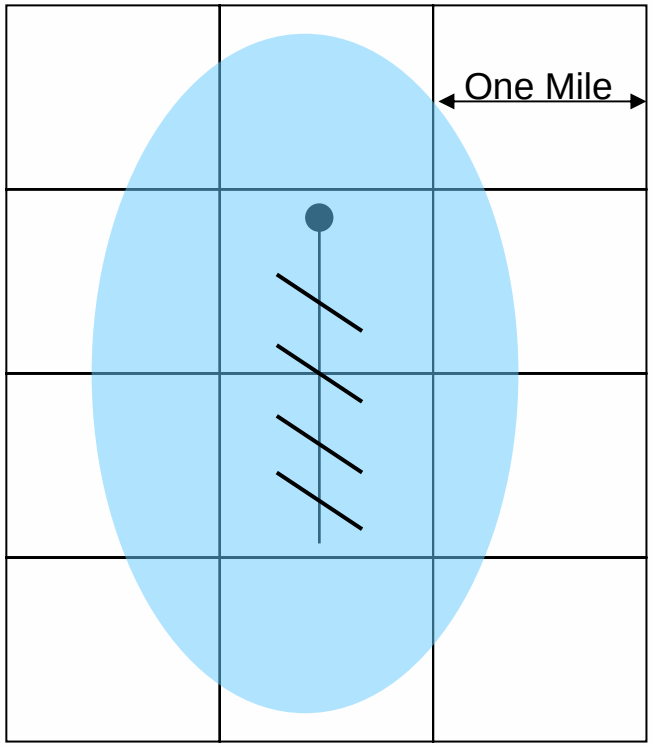


VSP data suggests that Bakken interval is at 2240 ms TWT at Klatt well location.

Tiltmeter – Fracture Stimulation Mapping

- Purpose – Map trends of fracture stimulation in a North Dakota Bakken horizontal
- Plan – Monitor tilt in earth with highly sensitive levels as fracture stimulation is pumped
- Contractor - Pinnacle
- Cost - $300 M for survey
- Execution – Initial stimulation interrupted due to mechanical failure. Second stimulation pumped recently with tiltmeters still in place
- Status – Processing second stimulation
- Marathon Contributors – Ken Dunek, Completions and Erin Wanner, Land

Comparison Technology – Tiltmeter And Surface Microseismic Mapping

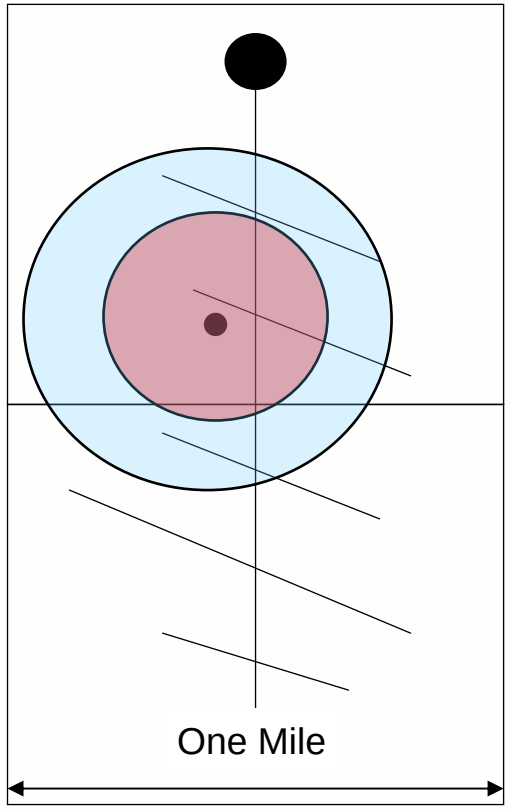


- An array of highly sensitive levels or radial pattern of geophones

- Tiltmeter/Surface Microseismic will show
  - Orientation
  - Order of treating

- Cost $250-$350K

Comparison Technology – Monitor Well Microseismic



- Listen to completion from a single point monitor well
- Higher resolution in map and vertical

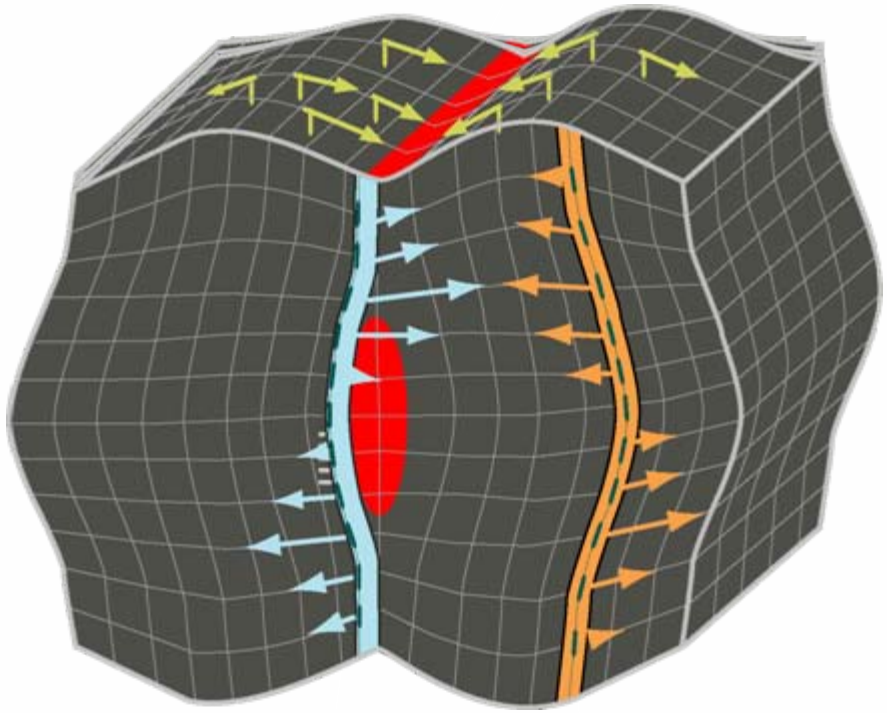
  vertical
- Low area coverage
- Cost $500K-$1500K+

Principles of Fracture Mapping

- **Tiltmeters are Essentially Deformation Gauges**
- **Tiltmeter are Highly Sensitive Levels that can measure in the Nano-radians**

Hydraulic fracture induces a characteristic deformation pattern

Induced tilt reflects the geometry and orientation of created hydraulic fracture



Courtesy of Pinnacle, Inc.

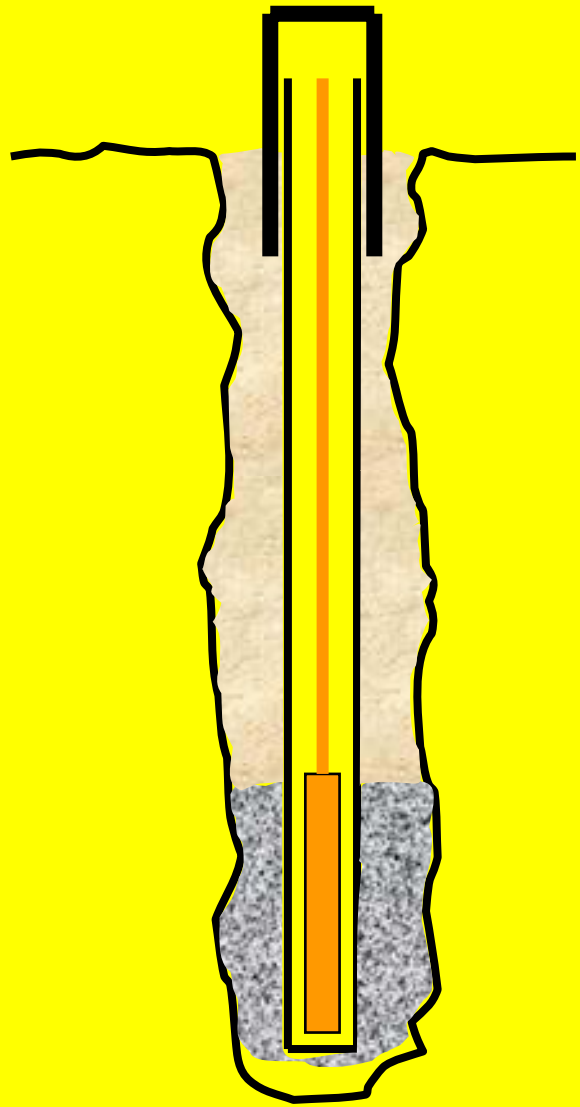
5500 Series Pinnacle Tiltmeter

Courtesy of Pinnacle, Inc.

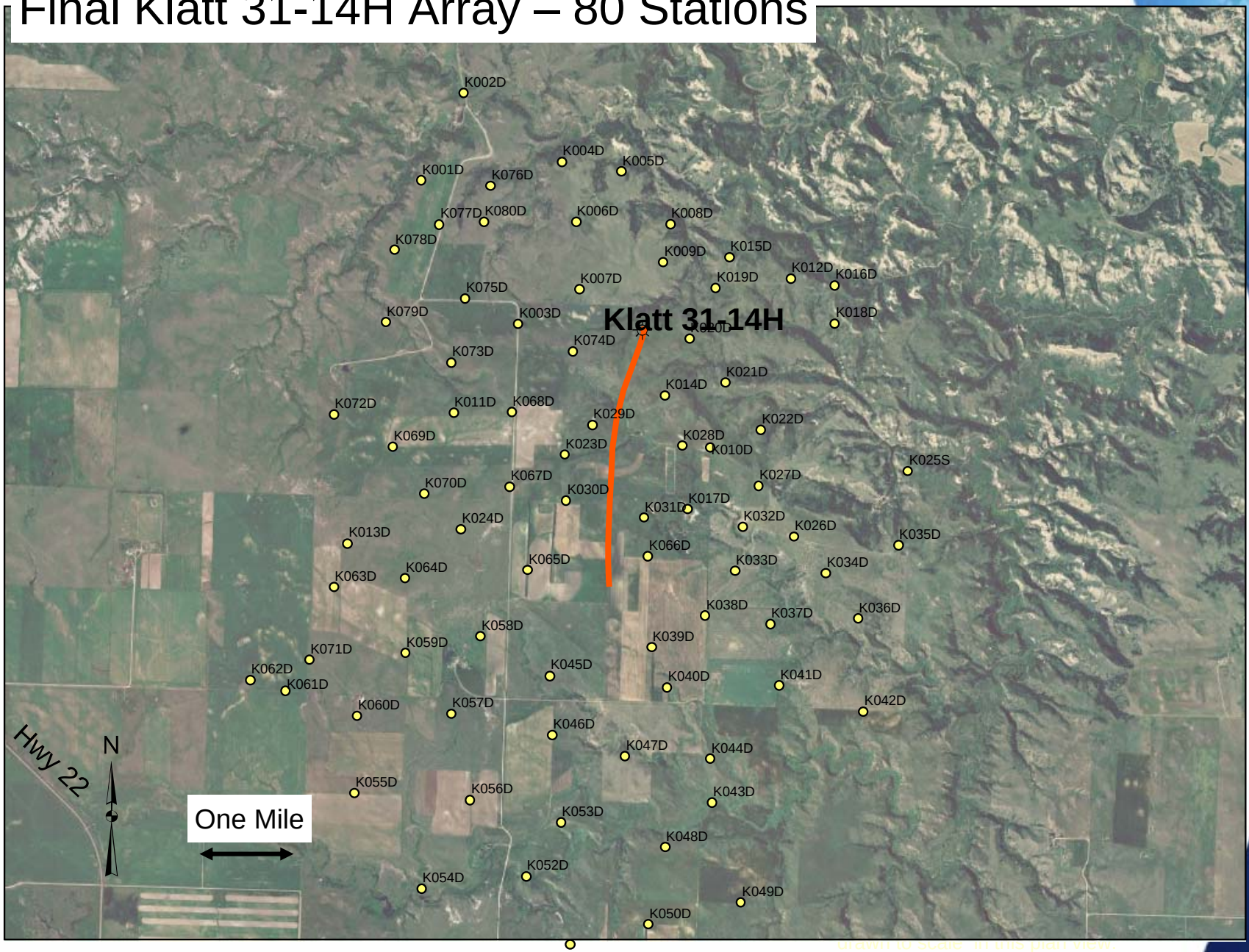
Installation

Manual Data Download Configuration

Automatic (Radio) Data Download Configuration



Final Klatt 31-14H Array – 80 Stations



Marathon Oil Company

Well Name: **KLATT 31-14H**
Prospect: **Hector**
County, St: **Dunn, North Dakota**
Location: **Section 14, T146N/R95W**

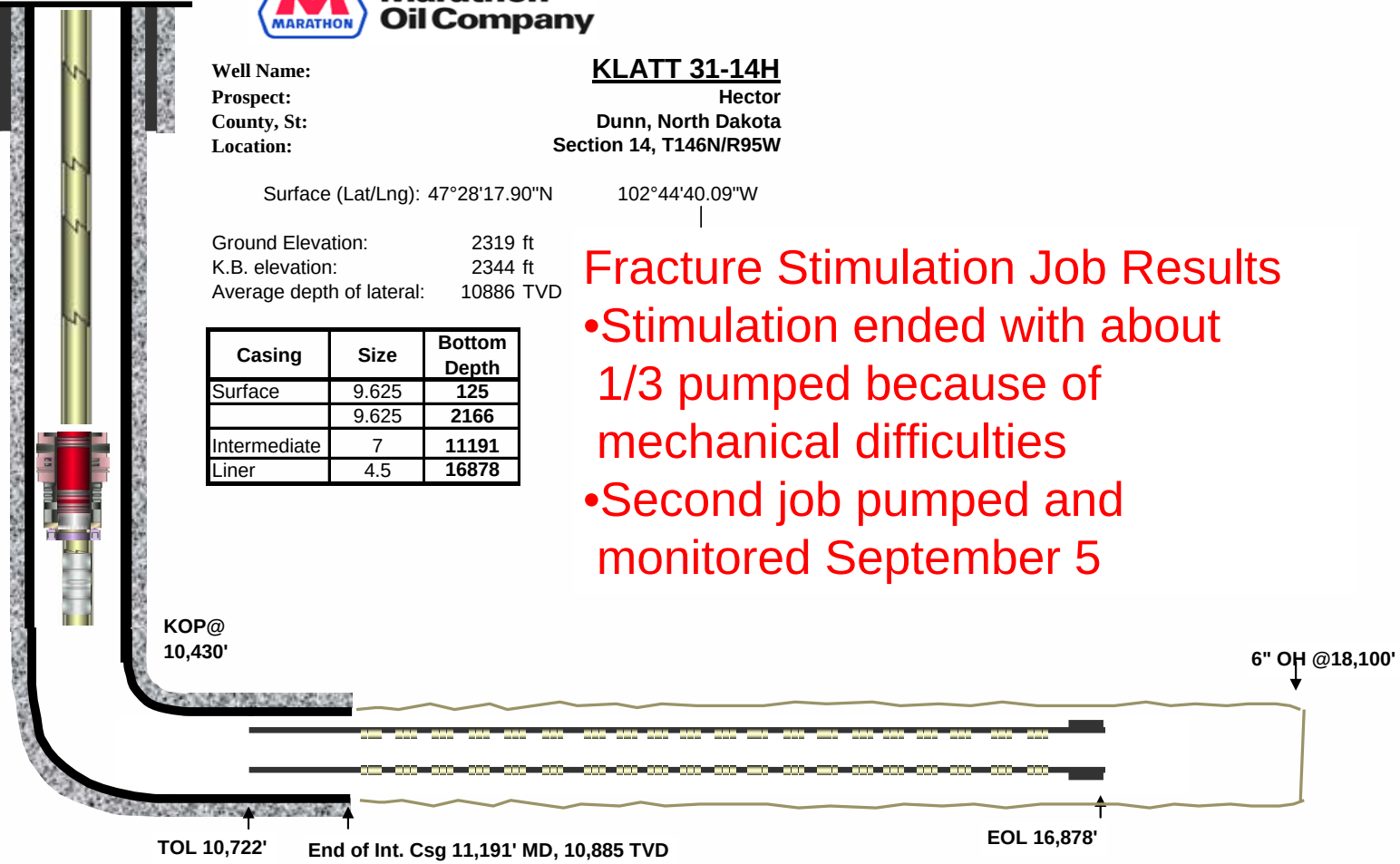
Surface (Lat/Lng): 47°28'17.90"N 102°44'40.09"W

Ground Elevation: 2319 ft
K.B. elevation: 2344 ft
Average depth of lateral: 10886 TVD

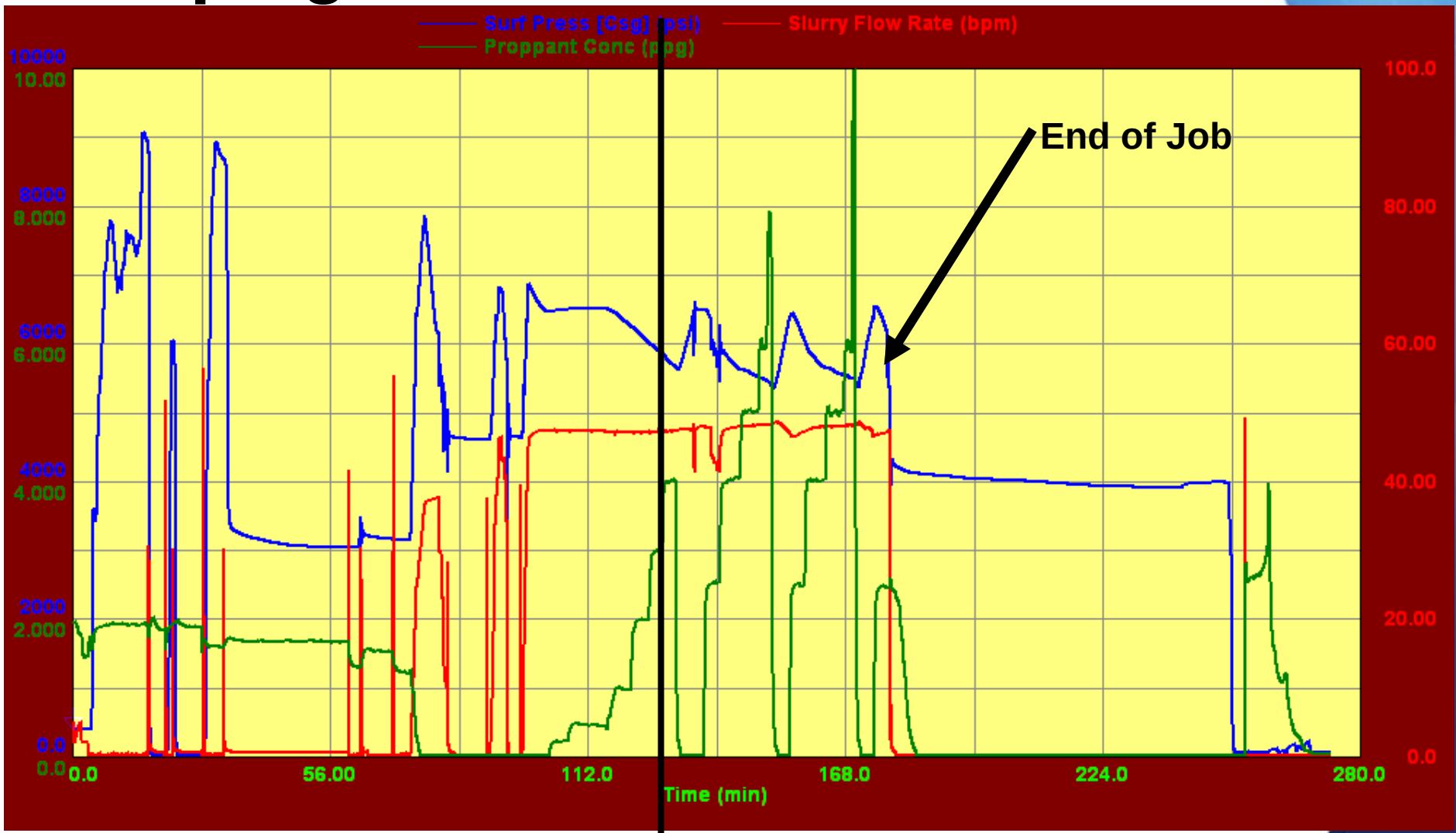
Casing	Size	Bottom Depth
Surface	9.625	**125**
	9.625	**2166**
Intermediate	7	**11191**
Liner	4.5	**16878**

Fracture Stimulation Job Results

- Stimulation ended with about 1/3 pumped because of mechanical difficulties
- Second job pumped and monitored September 5



Fracture Stimulation Pumping Schedule



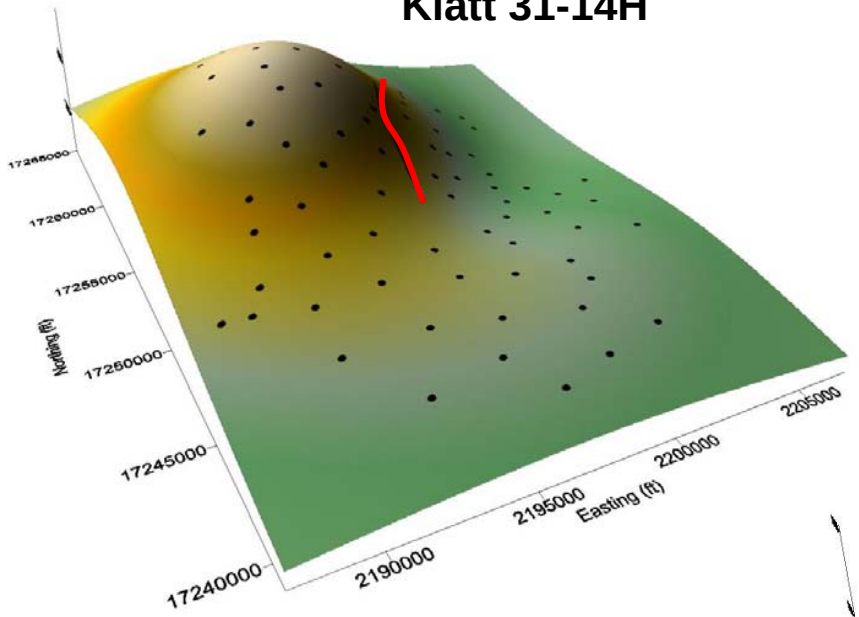
End 1st 40 min time step

After 1st 40 Minutes

Elevation (micro inches)

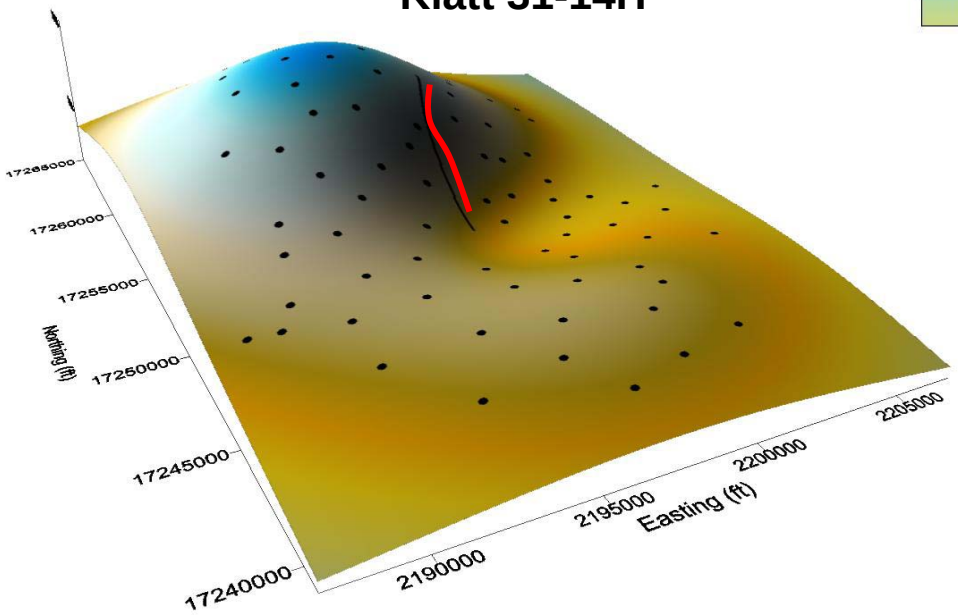
1000
800
600
400
200
0

Klatt 31-14H



After Full Treatment

Klatt 31-14H



Best-fit theoretical deformation visualization

Conclusions

- Both grant projects will accomplish their goals to employ technology toward the Bakken Play for better understanding of the area around the Klatt well and its completion.

- Both are deemed successful in acquiring useful data

- Both were performed at projected costs, efficiently and safely

- Data release will be in June 2008